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SCIENCE AND HISTORY: A SHORT CONTRIBUTION TO PHILOSOPHY[1]

By E. C. ANDREWS

GOVERNMENT GEOLOGIST OF NEW SOUTH WALES

IF the ordinary member of the Australian and New Zealand Association for the Advancement of Science were questioned concerning the main objects of the association, he or she would naturally reply that the title is self-explanatory, implying, on the one hand, coordination and correlation of scientific work by cooperation, and, on the other hand, the promotion of harmonious social relations both between scientific workers themselves and between them and the general public. The question thus naturally arises as to the scope of the association's activities and the best means of securing the desired cooperation. A glance at the names of the sections reveals a range of subjects for discussion varying from mathematics, physics, chemistry, geology and biology, to economics, medical science, social science, education, psychology and philosophy. Whether we consider philosophy in its general meaning as inclusive of psychology, epistemology, ontology, logic, esthetics and ethics, or in its narrower sense as synonymous with metaphysics, it is evident that the subjects considered are so diverse as to imply the possession either of decided versatility or of a broad grasp of scientific method on the part of one who would attempt the correlation of these subjects. Coherence of parts (sections), at least, is necessary, however, and in view of the present centrifugal movement towards specialization with its resultant divergency of interests and tendency to misunderstanding between the workers in the peripheral excrescences

[1] Abstract of the address of the president of the Australian and New Zealand Association for the Advancement of Science, Brisbane, 1930.

thus formed, it appears advisable to direct one's attention centripetally, as it were, and investigate the possibility of the existence of a principle common to, or underlying, all.

One of the main difficulties encountered in seeking to promote cooperation among the students of scientific method in the various branches of knowledge (disciplines), especially in connection with the study of possible underlying principles, is the tendency in the individual groups to undervalue the work done in branches far removed. The physicist and chemist in their syntheses do not appear to value sufficiently the vast gulf separating complex material mixtures from vital sense, or coenesthesis, and intellection in organisms. The idealist, on the other hand, does not appear to note that "bodies have not been successfully separated except into bodies, as real matter," and so on; the materialist does not appear to take sufficiently into account the fact that "bodies evolving account neither for themselves, their nature and their fundamental order of resemblance and difference, nor for the nature and origin of consciousness, nor even as yet for their becoming good for conscious beings." Moreover, the psychologist, the physiologist, the physicist, the biologist, claim too great a scope individually in the exploration of various activities, which, although consentaneous in action, nevertheless may only be described as psychoneural parallelisms. The true philosopher was he who was styled συνοπτικός by Plato, that is, he who takes a "synoptic" or comprehensive view of the universe as a whole.

Gilbert, the philosopher-geologist of America, advocated the extensive use of the "intellectual excursion" among workers, the peeping over the shoulders of one's colleagues, as it were, in all departments alike, to learn the lessons of tolerance, sympathy and the probable interrelatedness of all at base. Darwin's utilization in the "Origin" of the results of Mathews' work on "Naval Timber" is an example of the value of the "intellectual excursion." Especially valuable is this method in teaching the subjective nature of our knowledge, and the dependence on empiricism for the most definite advance in all branches, and in revealing the strangle-hold which traditions and beliefs acquired in infancy, childhood and youth have upon workers in all departments alike.

In order to obtain a clearer idea as to the advance which the universe, or at least the organic world, may be expected to make in the distant future, an ideal Observer is assumed, who visits the earth on several occasions—(1) in early Pre-Cambrian time, (2) during the whole of historical time and (3) say about one hundred or one thousand millions of years hence. He is possessed of human emotions and general sympathies; his vitality is perennial, yet his strength and endurance are only those of human beings; he journeys to the earth in a special self-contained chariot, but because of his physical limitations he can not approach the stellar bodies within very many millions of miles; he has no "early" training, as understood by human beings, but springs full-fledged intellectually, thereby being without either the help or the incubus of early traditions, beliefs and revelations, and without desires resulting from the "stable animal heritages" which had been grafted onto the evolving organisms one by one from the Pre-Cambrian. On the other hand, he has access to the whole of human knowledge, in mundane and sacred literature alike, wherewith to form a judgment by his sympathetic but disciplined mind.

His visit during the Pre-Cambrian leads him to consider the universe as a great inorganic cosmos, being a similar but more complete presentation of the beautiful and simple picture set out by Jeans in "The Universe around Us." The real meaning of such a cosmos, however, he is unable to divine, inasmuch as there is vouchsafed to him no sign of mentality such as his own, except in the suggestion presented of a grand industry, firmly established and running well apparently on its own.

His second visit extends throughout the historical period. At the outset he is impressed with the different aspect the earth has assumed. Where before were only the signs of inorganic activities, he now sees the organic world as it is to-day; nevertheless he is still ignorant of the results of geology, biology, psychology and history.

At the commencement he is inclined to agree with the ancient philosophers, namely, that there are four or five elements—air, water, earth, fire, ether—and that there are three forms of substance or fact, namely, matter, intelligence and an underlying and pervasive activity giving rise both to material and so-called immaterial manifestations.

As he dwells with men and follows the history of races through their successive stages of barbarism, fetichism, inquiry, reason and intellectual decrepitude, he notes that there is a general advance intellectually and ethically, in undulatory fashion, the scepter passing from one race to another as reason in each in turn abdicates its throne, to pass into a trough of hedonism and skepticism.

Geology and biology now come to his aid and reveal to him a similar progress in the organic world from insignificant beginnings in Pre-Cambrian time to the highest organic structures and mentality, nevertheless in undulatory fashion, with the scepter passing from one animal and plant race or group to another better fitted to carry aloft the torch of progress. In all,

however, the advance appears to be of the nature of an imposed gift.

Several other points impress him, namely, the tendency in man to specialization in scientific study; the tendency in each department of scientific research to reveal an underlying unity of activity, or a close interrelatedness of the objects of special study, nevertheless indicating, in each case, a still deeper underlying unity as yet undiscovered specifically and perceived only "as in a glass darkly"; the peculiar separate rather than disparate powers of the objective and subjective (subliminal) mental activities in organisms; also, the violent and determined opposition manifested generally to progress by organisms, the general opposition exhibited consciously to progress by man himself (considered as a whole) being well expressed in the epigrammatic line of Plautus, "Homo homini lupus." With all, however, he observes that this persistent opposition has never been able to block progress, although it has retarded it for short periods. History indicates also to the Observer that true advance comes only through cooperation, and that the latter stage can come only when man throws off "the clog of individuality and remembers that he has grand race connections."

The explanation of man's individualistic attitude is simple. The inorganic cosmos arrived first among the universal manifestations of an earlier activity. Thus, atomic, molecular, crystal and stellar worlds were developed before organic life. Gravitation, light, heat, electricity, magnetism, inertia, sound, and so on, are universal. The play of these inorganic activities was inexorable, and the earlier organic adjustments were directed in accordance with them. The organism had to meet the storm, the flood, the drought. Benevolence, sympathy and justice were unknown to them as such. The early organisms were to be rendered stable in this inorganic setting. On these stable organic heritages the subjective and objective mental activities developed with excessive slowness throughout geological time. Each stage in this parallel mental series developed in opposition, as it were, to the rigors of their physical environment. There were opportunities for consentaneousness of activity with these lower stable heritages, however, on the part of the higher qualities which became engrafted, or harnessed in parallel, one by one, and such harmony of adjustment or correspondence was accomplished sooner or later, but all unconsciously, on the part of the organism. An analogy may be seen in the difficulty experienced, so to speak, by an electron attaching itself to a rounded-out stable system, such as a noble (inert) gas, like helium or argon.

The comprehension of the universe is to come by inductive study, or, to revive a somewhat obsolete term, by perduction, implying an inductive-deductive process. Science advances in proportion to the capacity to develop organizing ideas whereby observations and experiments are "colligated into intelligible system." In scientific inquiry we endeavor to ascertain the plan upon which our material has been built. Facts are collected and experiments are conducted. After the plan is assumed to have been ascertained, the deductive method is employed to discover additional detail. It is generally recognized that an initial "flash of genius" is needed—the faculty of suggesting new and valuable hypotheses. No one at present knows why the flash of genius comes; it is possible, however, to indicate how to secure it. The mind must rigorously examine and check its data; an attitude of open-mindedness and freedom from "conservatism" must be observed, with a confident belief that the proper inference will come later after a period, as it were, of fallowness in "consciousness." In this inductive-deductive process, the objective mentality is the great inductive agent, the subjective apparently the deductive, the former giving scope for the abundant exercise of "free-will," the subjective opposing the way, so to speak, by its tremendous wealth of traditions, inherited beliefs and instincts, yet under proper discipline revealing a truly marvelous power of advance by the syllogistic method, once the correct premises have been presented to it with sufficient force.

All inductive study indicates an increasing appreciation of an underlying unity of phenomena, and "noümena," the disparateness of to-day being merely the separate, but related, of to-morrow. Physicists have broken down the partitions formerly supposed to separate mechanics, molecular physics, light, sound, heat, electricity. But a more subtle unity appears to underlie the proton, the electron and the energy. The biologist, the physiologist and the psychologist perceive the gradual development of complex syntheses from a primitive simplicity; the paleontologist tells us of the wonders of the factor of time in the development of each of the above syntheses, and his studies strongly indicate an underlying unity to the psychoneural (not psychophysical) parallelism exhibited in all organisms. Ethics, esthetics, art and calisthenics add their convergent testimony of correspondence and parallelism to biology, physiology and psychology. The physicist and the chemist perceive that as these higher correspondences or consentaneous activities are stripped off, one by one, the matter remains, that is, the material of the instrument upon which the tune of progress was played. Philosophy, in its broader acceptation, makes the "intellectual excursion" in order to bridge the gulf or gulfs separating the methodological parallelisms in organic activities. Phi-

losophy considers that these activities studied by science all belong to the universe; they all appear to be universal in their application under the proper conditions; in each department of research, moreover, an underlying unity is discovered; each succeeding generation of mankind discovers additional evidence of the interdependence and interrelatedness of all; it is, therefore, perhaps permissible to infer that all are the manifestations of a still deeper underlying unity, more far-reaching even than Einstein's law concerning the convertibility of matter into energy; moreover, since no energy can rise above its source, the universe, as the origin of all these activities, even of the "highest qualities" such as intellection and altruism, may be inferred to comprehend, sympathize with and to appreciate to the full their origin, their gradual synthesis and their peculiar resultant attributes. In this connection it appears probable that inductive study will reveal noümena as the totality of phenomena. Nevertheless, the study of nature, as generally understood, will, by itself, be insufficient. The inner meaning of the "cosmos" can not be expected to come from any inference or hypothesis which excludes from its premises "the intelligence in which nature, as it were, gathers herself up."

The Observer perceives that universal progress has been unbroken and unfailing, and that man, or some similar organism, will penetrate to the inner meaning of "things." Merriam considers a related point in an interesting article in a recent number of *Scribner's* (1927) entitled "Are the Days of Creation Ended?" The conditions for man to occupy the dominant position appear to be that he shall think and act impersonally; that he shall employ the inductive method in the broader sense as mentioned above; that he preserve his "stable heritages" intact, and that he appreciate time in generous terms as an essential factor in universal progress. The knowledge that was Newton's and Darwin's is to be but a basement stone, as it were, to the mighty temple of knowledge whose peak is to pierce the clouds. The greatest intellect, or the mind of the seer, is but a base upon which greater and grander examples are to rise and rest in countless thousands.

SOME SCIENTIFIC INSTRUMENT MAKERS OF THE EIGHTEENTH CENTURY[1]

By ROBERT S. WHIPPLE

ALTHOUGH numerous references are found in early British manuscripts to instruments of an elementary kind, chiefly for the determination of time or position, there is little evidence that before the sixteenth century scientific instrument making as a craft had obtained a position of any importance in Great Britain. The demand for instruments to assist navigation became more insistent as new lands were discovered and the length of the voyages increased.

Gradually the professional scientific instrument maker came into existence, two of the more distinguished being Humphrey Cole, the maker of the astrolabe used by Sir Francis Drake, and Elias Allen, the maker of Oughtred's double horizontal dial. In a book by Oughtred, dated 1632, describing the double horizontal dial, it is stated that it is printed for Elias Allen, "Maker of these and all other Mathematical Instruments, and are to be sold at his Shop over against St. Clements Church without Temple-barr."

With the discovery of the telescope in 1608 and its development by Galileo in the following years a great impetus was given to the instrument-making industry. Although Gregory and Newton propounded the reflecting telescopes known by their names in 1663 and 1666, they were unable to find makers capable of developing their ideas. Newton made his own instruments, but it was not until about 1730 that John Short, of Edinburgh, succeeded in making a Gregorian telescope.

The latter half of the seventeenth century was a great period of scientific development. Experimental science, under its leaders Boyle, Hooke, Newton and others, created a demand for scientific instruments which could only be satisfied by skilled craftsmen. The work of Hooke and Leeuwenhoek did much to develop the microscope and to draw attention to the possibilities of the instrument. Fortunately an instrument made about 1670, and somewhat similar in its details to that described and illustrated in Hooke's "Micrographia" (1655), has been preserved, and by Mr. Court's courtesy is exhibited here this evening. The evidence is, I think, convincing that this instrument was made by Christopher Cocks, the well-known telescope maker, who lived in Long Acre, and of whose telescopes there are at least three in existence. It is known that in March, 1672, Cocks was ordered to make a four- or five-foot Newtonian reflecting telescope, but the instrument was not successful. About 1680 he was admitted a freeman of the Spectacle Makers' Company.

[1] Address given at the weekly evening meeting of the Royal Institution of Great Britain, Friday, May 23, 1930. Lord Rayleigh, Sc.D., F.R.S., manager and vice-president, in the chair.

Owing to the publication of the "Micrographia" with its description of Hooke's microscope, great interest was created in microscopical work, and a demand arose for microscopes. Owing to the high quality of the optical and mechanical work the English microscope won a high reputation.

The greatest of the English instrument makers who bridge the seventeenth and eighteenth centuries is undoubtedly John Marshall. Nothing is known of his early life, but part of a diary recently discovered in the British Museum by Mr. H. W. Robinson, by whose courtesy I am able to publish an extract, has thrown an interesting sidelight upon Marshall's career. The record covers five years of Hooke's life, 1688 to 1693, with the exception of some few months, and was thought to be the diary of James Petiver, an apothecary friend of Hooke. Mr. Robinson has been able to prove that it was written by Hooke. The following is an extract, December 14, 1688: "One John Marshall who told me he was Dunning apprentice & now worked at turning at the 3 keys in Ivy Lane came to shew me some microscopes of his own making he told me Mr. Boyle had bought such of him." He appears to have set up later at the sign of the Gun as a maker of spectacles and microscopes, and there is little doubt that the microscopes were of the Hooke type. By 1690 he had built up a large business and had introduced a new method of grinding lenses on brass tools. Marshall's double microscope was undoubtedly the greatest advance made in microscope construction for many years. The instrument was fitted with coarse and fine focusing adjustments, and for the first time the limb which carried the eyepiece, the object-glass and the object formed one complete system which could be inclined as one unit. All the features are retained in the modern instrument.

The first outstanding English instrument maker in the eighteenth century is undoubtedly Benjamin Martin, a man who, as far as is known, was not apprenticed to the trade. He was born at Worplesdon, Surrey, in 1704, and began life as a plowboy, later becoming a teacher of the "three Rs" at Guildford. He devoted his spare time to the study of mathematics. A legacy of £500 relieved him from the necessity of teaching and enabled him to travel and lecture. He appears to have assisted at the lectures given by Dr. J. T. Desaguliers, which were eagerly attended by the fashionable world and were illustrated by experiments. Horne, afterwards president of Magdalen College, Oxford, sarcastically remarked that Ben Martin "who having attended Dr. Desaguliers' fine raree gallantry show for some years in the capacity of a turnspit, has, it seems, taken it into his head to set up for a philosopher." This is a hit at Martin's literary efforts, because he proceeded to publish a large number of text-books dealing with a great range of subjects. When it is considered that Martin was a self-educated man, the extent and thoroughness of his knowledge as shown in his publications are remarkable. He appears to have lived some time at Chichester, where he kept a school, and also wrote several elementary text-books and pamphlets describing scientific instruments. There is little doubt that he commenced to make scientific instruments in Chichester, not improbably being asked by the readers of his books where it would be possible to obtain the instruments mentioned.

About 1750 he moved to London to a house in Fleet Street, three doors below Crane Court, where he became famous as a scientific instrument and spectacle maker at the sign of "Hadley's Quadrant and Visual Glasses." Martin was essentially a teacher, and continued to write after he had made his home in London. The books impress one with the care he takes to make every individual step in an explanation clear, and with the detailed drawings and references with which he explains the construction and use of an instrument. This is strikingly illustrated in his description of the various orreries he constructed. The orrery was almost the latest scientific novelty, and Martin appears to have been much impressed with the educational possibilities of the instrument. In his "Young Gentleman and Lady's Philosophy in a continued survey of the works of Nature and Art"—a book which had a great vogue—he uses planetaria to describe the difference between the Ptolemaic and Copernican systems, and the phenomena of eclipses, etc. He was evidently prepared to supply either form of planetarium to suit his customers' wishes. In one of his tracts published in 1771, "The Description and Use of an Orrery of a new Construction," he gives full details of the capabilities of the instrument, and also "the theory of calculation for the wheel-work of an orrery to the most extreme Degree of Accuracy." The prices of the instruments ranged from £12 12s. upwards, depending on the number of bodies demonstrated, and the accuracy of their movements, or as Martin himself states "proportional to the work." That Martin must have continued to lecture till late in life is shown by the fact that the apparatus made is adapted to show "all the Phænomena [*sic*] of the Transits of Mercury and Venus over the Face of the Sun such as I shewed in Public to Thousands on the late memorable instance of 1769."

In 1740 Martin published a useful text-book on optics, "A New and Compendious System of Optics," and in many other writings took immense trouble to explain optical systems and instruments. His microscopes and especially his cabinets containing two or three instruments of various types were much sought

after and still remain as examples of first-class workmanship and ingenuity. There is little doubt that he invented the drum type of microscope which had a great vogue, and is still made in large numbers on the Continent. If the invention of the glass micrometer as applied to a microscope was not actually due to him he was undoubtedly one of the first to employ it. He was also one of the first to apply rack and pinion focusing adjustments to the compound microscope, and to fit inclining movements to the pillar carrying the stage and mirror.

It is a cause of wonder to me how Martin was able to produce such a large number of books. The Dictionary of National Biography mentions thirty-one, although some of them are only leaflets. Many of his books passed through several editions, and at least one was translated into French. They undoubtedly helped to popularize science and to create an interest in scientific instruments. Shortly before his death at the age of seventy-seven he took his son into partnership, and unaware of the state of his affairs was adjudged bankrupt. He thereupon attempted suicide, and the wound hastened his death. His valuable collection of fossils and curiosities was sold by public auction for a trifling sum—a tragic ending to a more than usually successful career.

George Adams, the elder, perhaps the greatest of English scientific instrument makers, was born about 1704. It is known that he was apprenticed in 1718, and that he was established in business on his own account at Tycho Brahe's Head in Fleet Street in 1735. It is also known that he was making instruments for the East India Company in 1735–36. He obtained a world-wide reputation as a maker of globes. In 1766 he published the first edition of his book "A Treatise describing and explaining the construction and use of new celestial and terrestrial globes." Dr. Samuel Johnson, the lexicographer, wrote the dedication to the King, and for so doing received a present of "very curious meteorological instruments of a new and ingenuous construction." The book had a great vogue, passing through thirty editions.

Adams was essentially a mechanic, and delighted in good workmanship. There can be little doubt, I think, that the microscope was his favorite instrument, and he developed several types of it. In 1746 he published his "Micrographia Illustrata: or The Knowledge of the Microscope explained in several New Inventions, etc." The preface to the "Micrographia Illustrata" emphasizes the religious side of Adams's character, and also shows that he must have had the artistic and poetic temperament highly developed.

The first edition contained an account of a "New Universal Microscope," which was made to an entirely original design, the object being, as Adams states, "to have a Microscope which would be Portable and Universal, that is to say, ONE ONLY INSTRUMENT, by which all Sorts of minute Objects might be observ'd." The microscope was provided with six single lenses of different foci with a common focusing screw. Adams remarked of this focusing screw that it "is to be turned as your hands and arms are resting on the table, which is a conveniency to be met with in no other Microscope." A second edition of the "Micrographia Illustrata" appeared in 1747, and a fourth in 1771. Despite exhaustive researches it has not been possible to find a copy of the third edition—if it were ever published.

The fourth edition commences with a description of the variable microscope, of which Adams was evidently very proud. He states that "We owe the construction of the Variable Microscope to the ingenuity and generosity of a noble person," and we know that the "noble person" was the Earl of Bute. By having a compound eye lens and by introducing an auxiliary lens placed some distance above the objective the definition was improved. Adams also introduced the method of screwing two or three objective lenses one on top of the other. By drawing up the eye-piece relative to the object glass the power of the combination could be altered—hence the name "variable." Adams, in common with Martin and other makers of the period, developed the solar microscope with the large mirror projecting out of the window, by means of which brilliant illumination could be obtained and magnified images of the object projected on to a screen.

Adams appears to have given a great deal of consideration to the method of measuring the magnification of microscopes, and illustrates in detail in the "Micrographia Illustrata" (Plate 14, fourth edition) various micrometers for this purpose, amongst others the micrometer he made in 1761 for the silver microscope of George III. This instrument originally formed part of the King's Collection, and is now in the Lewis Evans Collection. It has been described by Messrs. Clay and Court at some length.[2] Although the details of workmanship in this instrument are excellent, the instrument as a whole must be regarded as an ornament rather than a serious contribution to microscopy. Such is not the case with the earlier instrument made for the King when Prince of Wales, and known as the "Prince of Wales" microscope. It is particularly interesting as embodying the method of mounting a microscope on trunnions—perhaps, as Clay and Court remark, the first microscope so sup-

[2] R. S. Clay and T. H. Court, "Two Microscopes made by G. Adams for King George III," *Journ. R. Micr. Soc.*, 1926, pp. 268–273, and *Supplementary Note, Journ. R. Micr. Soc.*, 1927, p. 255.

ported. There are three stages, one of which is of great interest, having micrometers registering in two directions at right angles. The screws have 100 threads to the inch, and the scales on the heads are divided into 100 parts, so that the micrometers read to 1-1000 in. A second stage was intended to carry a frog for demonstrations on the circulation of the blood. It is a matter of general knowledge that King George III was keenly interested in scientific matters and wished that his family should be instructed in science. Dr. Demainbray commenced to teach the royal family in 1754, and appears to have used for this purpose the apparatus which formed the major part of what is known as the King George III Collection. The instruments in the collection were catalogued in a manuscript book which is still preserved in the Kew Observatory and also in a catalogue which is now in the Science Museum at South Kensington. The instruments were housed at the Kew Observatory until 1841, when they were transferred to King's College, London. In 1925 they were removed to the Science Museum at South Kensington, where the majority of them can be studied. The story of the collection was told in some detail in a paper before the Optical Convention of 1926.[3] The majority of the instruments intended for instructional purposes were made by George Adams, although few of them bear his name. Fortunately two books of instructions have been preserved, and it is by means of these that it is possible to state that most of the instruments were made by Adams.[4]

The instructions consist of two manuscript books about 19 in. by 13 in., with two small books about 12 in. by 9 in. The pages of the latter are of blue paper, on which are pasted white sheets on which the illustrations have been drawn. One book is entitled: "A Description of an apparatus for explaining the Principles of Mechanicks made for His Majesty King George the Third by George Adams, Mathematical Instrument Maker to His Majesty. In Fleet Street, London, 1762." The second book is entitled: "A Description of the Pneumatic Apparatus made by George Adams in Fleet Street, London, 1761." In the case of the "Mechanicks" the final sheets of drawings were in course of preparation, the outlines having been drawn, but the shading is incomplete and reference figures have not been inserted. It was evidently intended that the sheets of drawings should be bound as a book to accompany the instructions, and probably that the latter should be bound also when the drawings were completed, but these were never finished. In the case of the "Pneumatics," drawings on plates the same size as the manuscript (19 in. by 13 in.) were in course of preparation, and those that are finished are excellently drawn. In the case of both books it was no doubt intended to have the manuscripts bound—as they are now a series of loose leaves in rough covers—but this was never done. The two books containing the comparatively rough drawings appear to have been the center around which Adams built up the experimental courses. In the case of the "Mechanicks" a little mathematical work is also included, although the course is essentially experimental and based on Desaguliers' translation of the classical work of 's Gravesande, the distinguished professor of mathematics of Leyden.[5]

Adams apparently cut out many of the illustrations from Desaguliers' book, and added pencil or ink modifications to guide the workman. An example of a modification of this kind is found in an apparatus intended to demonstrate experiments on pendulums and the impact of bodies; it is generally known as "'s Gravesande table." The central illustration in Plate 25 of Desaguliers' book has been cut out and modified. The additions are shown by the cross hatching, but the parts removed have been carefully cut away before mounting. The finished instrument can be seen at South Kensington, and comparing the original design with that made by Adams, one has to admit that the latter is more graceful than the original. The workmanship of the whole of this piece of apparatus is excellent. Adams evidently considered the cost of making apparatus, because several modifications are introduced with a view to reducing labor. The drawing of a table is shortened in pencil, with the words "Too long" written against it, and there are small pencil sketches at the side showing alterations. A ring is made to take the place of a fairly elaborate handle, and a simple glass basin is used instead of a brass bowl.

There can, I think, be little doubt that, judging from the large number of sketches that are dimensional, they must have formed the actual drawings from which the apparatus was built. Not improbably the workman had made some of the instruments previously for other customers, so that he did not require detailed drawings. The work of making the instruments may have spread over a few years. In the

[3] R. S. Whipple, "An Old Catalogue, and What it Tells us of the Scientific Instruments and Curios Collected by Queen Charlotte and King George III," *Proc. of the Optical Convention*, part II, 1926.

[4] It is by the courtesy of the Delegacy of King's College and the Director of the Science Museum that I have been able to examine these books.

[5] "Mathematical Elements of Natural Philosophy, confirmed by Experiments: or an introduction to Sir Isaac Newton's Philosophy." Written in Latin by the late W. James 's Gravesande, LL.D., professor of mathematics at Leyden, and F.R.S. Translated into English by the late J. T. Desaguliers, LL.D., F.R.S., and published by his son, J. T. Desaguliers. Sixth edition, 1747.

case of one of the pneumatic instruments mention is made of apparatus previously supplied and now "in one of the cabinets of the Palace at Richmond."

All through both books references are made to various scientific authors; for example, when discussing the Archimedean screw five references are given.

One of the most interesting instruments shown in detail is the rotating speculum suggested by Searson as an artificial horizon. Full details of the construction are given, and a manuscript copy of Emmerson's paper in the *Philosophical Transactions,* 47: 352, is included with the manuscript papers of the collection. Adams commences the description of the instrument with a short introduction:

> I recieved this invention from the late Sir Jacob Ackworth, first Commissioner of his late Majesties Royal Navy; soon after the inventor Mr. Searson was unfortunately lost on board His Majesties Ship the *Victory.*

Adams' mechanical ability shows itself in his instructions as to lubrication:

> It is necessary to put a drop of sweet Oil into the concave Steel polished segment of a sphere, for if the speculum be whirled without Oil it does not spin much above ten or twelve minutes, with Oil it will spin generally 36 minutes.

Only two of the illustrations are actually signed by Adams, although there is little doubt that the various notes are in his writing. There is a short four-page manuscript slipped into one of the books, which is a sheet of instructions with regard to some details of an instrument. Adams presumably wrote his notes out in this manner, and they were afterwards transcribed in the elaborate copy-book writing of the instructions.

The fourth edition of the "Micrographia Illustrata" is dated 1771, and Adams died in 1773. He must have lived a full life as, judging by the large number of instruments that may be found bearing his name, and by the "Catalogue of Mathematical, Philosophical and Optical Instruments" published in the end of the "Micrographia Illustrata," he must have had a large and flourishing business.

He left it to a son—George (born in 1750)—who added greatly to the prestige of the firm. He was a cultured man, and a favorite at court. He wrote a large number of books, the majority of which passed through more than one edition. The most famous of his books was his "Essays on the Microscope," published in 1787. In the preface he states frankly that he had intended to confine himself to a republication of his father's work, the "Micrographia Illustrata," but that knowledge of the subject had increased so much since his father wrote, that he felt the book had to be rewritten. Discussing the natural history side of the subject he states that he has endeavored to correct some of the faults in arrangement, etc., "by arranging the subjects in systematic order, and by introducing the microscopic reader to the system of Linnaeus, as far as it relates to insects." Chapter I is an extremely interesting history of the microscope, as observed by one who lived close to many of the inventions. In it he mentions that he invented an improved form of the lucernal microscope in 1774. In Chapter III he mentions that "this microscope was originally thought of, and in fact executed by my father; I have, however, so improved and altered it, both in construction and form, as to render it altogether a different instrument." He also mentions that "the great demand I have had for them has fully repaid my pains and expenses [*sic*] in bringing it to its present state of perfection." The lucernal was a simple compact form of projection microscope which met with general approval as an instrument which could be conveniently demonstrated to a number of people at the same time.

A second and enlarged edition of the "Micrographia Illustrata" appeared in 1798, edited with great care by F. Kanmacher. This editor in a footnote dwells on the fact that Adams had not given full credit to Benjamin Martin for what he had done to develop the microscope. Adams's "Geometrical and Graphical Essays," first published in 1790, was an extremely useful text-book for surveyors, civilian and military. The lectures on "Natural and Experimental Philosophy," first published in 1794, in five volumes, very nearly cover the range of physics as then understood—or, in the words of the subtitle, "describing in a familiar and easy manner the principal phenomena of nature, and showing that they all cooperate in displaying the goodness, wisdom and power of God." One is much impressed with the immense amount of work involved in the preparation of these books, for they are all full of individuality. The lectures were evidently written under difficulties. In the preface the author mentions "During the composition of these Lectures I have had to attend to the grateful calls of daily business, and have struggled with much weakness and langour." He passed away on August 14, 1795. We learn from an editorial note to the second edition of the "Essays on the Microscope" that Adams at the time of his death was preparing a new edition and that he had other books in view. After his death his books and instruments were sold by auction, and the stock and copyright of his books were purchased by the brothers W. and S. Jones. William Jones was responsible for the editorial work and the republishing of several

editions of Adams's books. The firm also continued to make instruments to the Adams design for many years.

The manuscripts and plates of Adams the elder were inherited by his widow, who gave them to her younger son Dudley. He edited a thirtieth edition of the "Treatise on the Globes," published in 1810. It is said that he had intended to publish another edition of the "Micrographia Illustrata," but it is not improbable that the revised edition (1798) of his brother's "Essays on the Microscope" rendered this unnecessary. Dudley Adams appears to have continued in the instrument business, as Mr. Court possesses a statement written on the back of a shop print, about 1800, of the wholesale trade terms for telescopes. These were evidently of the short brass draw-tube type which Dudley Adams had developed. The note attached to the price list states that "the object glasses not being single but achromatic" shows that non-achromatic glasses were sometimes sold.

Time has only allowed me to dwell in detail on four instrument makers in this century so full of scientific development. Their names are not so well known to the general public as those of Doliond, Herschel and Ramsden. Nevertheless the men whose work I have briefly described did an immense amount to popularize science and to raise the standard of scientific instrument craftsmanship. How world-wide this reputation for good work became is best seen by the number of instruments of English eighteenth century workmanship treasured in the Continental museums.

SCIENTIFIC EVENTS

THE INTERNATIONAL VETERINARY CONGRESS

THE International Veterinary Congress, which met in London during the first week in August, passed resolutions covering most of the subjects discussed on the previous days.

Delegates decided to accept the invitation of the American Veterinary Medical Association to hold the next congress in the United States in 1934, probably at Boston. Cheers greeted the announcement that the Budapest Prize, a gold medal, richly wrought, which was instituted when the congress met in that city, had been awarded to Professor Hutyra and Professor Marek, of Budapest, for the best work on veterinary science since the last congress. This consisted of a revised edition of a volume on the "Pathology of the Internal Diseases of Domesticated Animals." Professor Hutyra, who responded on behalf of himself and his colleague, is president of the permanent committee of the congress, rector of the Royal Hungarian Veterinary High School, and a member of the Upper House, Budapest.

Resolutions were carried with acclamation thanking the British Government and many individuals for their hospitality to delegates, and to Sir John McFadyean, of Leatherhead, for presiding. It was decided to increase the personnel of the permanent commission from 25 to 40.

In a resolution on foot-and-mouth disease, the congress urged that every country should determine the type of virus present in each outbreak. The most efficient disinfecting agents were moist heat and sunlight, and the chemical agents potassium, sodium hydrate and formalin. The value of passive immunity, according to the resolution, had been established, and its use in practice under favorable circumstances should be encouraged. It was desirable that all possible efforts should be made to discover an efficient method of active immunization.

The wide-spread occurrence of infectious abortion of cattle in all civilized countries led the congress to suggest an international scientific investigation within the purview of the International Bureau for Animal Diseases in Paris. The congress recommended the creation of a special section for meat and milk in the next congress. It also emphasized the necessity of state regulation for the control of the health of domestic animals, and for the title of veterinary surgeon to be protected by a recognized diploma.

The next resolution expressed the view that sufficient knowledge of practicable methods was now available to eradicate rinderpest within a reasonable period of time in any country which would provide adequate facilities for their application, and the congress urged all governments to cooperate to this end.

Resolutions were also carried concerning the teaching of zootechnics; the need for establishing in every country an organization similar to the German for combating diseases of the new-born animals, and the urgency for drawing up rules for the control and standardization of veterinary biological products.

INTRODUCTION INTO THE UNITED STATES OF PLANTS RESISTANT TO DISEASE

A STATEMENT given out by the U. S. Department of Agriculture states that two explorers of the department, H. L. Westover and K. A. Ryerson, are in North Africa looking for wilt-resistant alfalfas and fruits adapted to the United States. They will later continue their exploration in Spain.

Mr. Westover, a forage crop specialist, is now making preliminary surveys in the principal alfalfa-

growing districts of Morocco, Algeria and Tunisia, in order to return to Spain for the first portion of his collection trip. He will return later to these countries to collect the seeds from the harvest which is not yet ready. He made a similar exploration in southwestern Asia, the heart of the alfalfa district, last year, and brought back many varieties of alfalfa now being tested by the department for wilt resistance.

Mr. Ryerson, head of the Office of Foreign Plant Introduction, is looking for varieties of peaches and other fruits that will be of value in this country. He seeks particularly to recover some American varieties of peaches that have disappeared from production in this country after having become established abroad. He originally planned to join Dr. Frederic T. Bioletti, professor of viticulture at the University of California, who has been conducting an exploration for grapes and apricots for the department and the university in North Africa.

Professor Bioletti's illness has caused some alteration of these plans, so that Mr. Ryerson will have to take charge of the completion of his work. The preliminary work in connection with apricots has been completed, and there remains only the harvest of the seeds and scions. The grape work has not reached so advanced a stage but it is well under way.

Four or five years ago bacterial wilt appeared in the heart of the alfalfa belt and threatened to exterminate this crop. The San Joaquin Valley of California has suffered heavy losses from wilt. Losses in Kansas in 1927–28 amounted to about 15 per cent. and for the last three years in Iowa and Missouri to about 25 per cent. In Minnesota, Nebraska and Missouri wilt has worked hand in hand with crown rot, combining to bring losses up to 50 per cent. of the crop. In Colorado it is the most destructive disease of alfalfa, one field suffering loss of 80 per cent. of the plants. Wherever prevalent, wilt has done its greatest damage in humid climates and on irrigated lands.

THE NATIONAL INSTITUTE OF HEALTH

THE National Institute of Health has issued the following statement:

By the act of Congress approved May 26, 1930, entitled "An act to establish and operate a national institute of health, to create a system of fellowships in said institute, and to authorize the government to accept donations for use in ascertaining the cause, prevention and cure of disease affecting human beings, and for other purposes," the Hygienic Laboratory will hereafter be known as the National Institute of Health of the United States Public Health Service. The author of this measure was Senator Joseph E. Ransdell, of Louisiana.

The general purposes of the act are to provide large facilities for investigations of diseases of man and matters pertaining to the public health, to encourage research and the training of individuals engaged therein, to enable the government to accept bequests in aid thereof, and to bring about cooperation with scientific institutions in the prosecution of research work.

Public health investigations by the Public Health Service were first authorized in 1901. Since then substantial progress has been made and many new facts have been discovered which have had an important bearing on the prevention and control of disease. The necessity for this work far outstripped the facilities for its conduct. Under the above-mentioned authority, these facilities may be greatly enlarged.

In its development the new institute will have the advantage of the traditions of the Hygienic Laboratory. In reality the Hygienic Laboratory becomes the National Institute of Health which, with enlarged facilities, will be devoted to investigations of the underlying problems not only of communicable diseases but of degenerative diseases and environmental conditions affecting health.

In aid of this work the Secretary of the Treasury may hereafter accept gifts to be held in trust and used for the purposes mentioned; the expenditures to be safeguarded in all respects as are other governmental funds. These gifts may also be used for the establishment of fellowships to encourage individual scientists.

Appointments and services under these fellowships will be governed by laws and regulations affecting the United States Public Health Service. Individual ability is the most valuable asset of a people of a country. The object is to encourage postgraduates of extraordinary ability and to aid them to follow permanently their scientific bent in the interests of humanity.

In order that those who make gifts may have a living part in the development of the institute, provision is made whereby donations of $500,000 or over will be acknowledged permanently by the establishment within the institute of suitable memorials.

The Secretary of the Treasury has recently accepted a gift of $100,000 offered by the Chemical Foundation, Inc., through its president, Francis P. Garvan, under the provisions of the act of May 26, 1930, which authorizes the government to accept donations and to create a system of fellowships, etc., in the National Institute of Health. The condition is made that the income from this fund be used for one or more fellowships in basic chemical research in matters pertaining to public health, the details of which are left to the Surgeon-General and his advisory committee. The act provides that conditional

gifts such as this may be accepted by the Secretary of the Treasury if recommended by the Surgeon-General and the National Advisory Health Council.

THE CINCINNATI MEETING OF THE AMERICAN CHEMICAL SOCIETY

THE meeting of the American Chemical Society at Cincinnati will open on September 8, continuing for the following four days.

On Monday at 2 o'clock there will be a meeting of the council and at seven in the evening there will be a subscription dinner, reception and dance at the Hotel Gibson for members and their guests.

On Tuesday there will be two symposia: Group 1 meeting under the auspices of the divisions of industrial and engineering, organic and cellulose chemistry and Group 2 meeting under the auspices of the division of physical and inorganic chemistry. The subject of the former will be "Industrial Fermentation," the speakers and subjects being: E. I. Fulmer, "The Chemical Approach to Problems of Fermentation"; A. A. Backhaus, "Ethyl Alcohol"; J. F. Garrett, "Lactic Acid"; Chas. N. Frey, "The History and Development of the Modern Yeast Industry"; C. L. Gabriel and F. M. Crawford, "The Development of the Butyl Acetonic Fermentation Industry"; F. C. Blanck, "Fermentations in the Food Industries"; A. M. Buswell, "The Production of Fuel Gas by Anaerobic Fermentations"; O. E. May and H. T. Herrick, "Some Minor Industrial Fermentations."

The subject of the second symposium will be "Non-aqueous Solutions." Those who will take part are: Charles A. Kraus, who will speak on "Reduction in Non-Aqueous Solvents"; Arthur W. Davidson, "An Introduction to the Chemistry of Acetic Acid Solutions"; F. W. Bergstrom, "Bases of the Ammonia System"; George Scatchard, "Equilibrium in Non-Electrolyte Mixtures in Relation to the Densities and the Vapor Pressures of the Component"; J. A. Wilkinson, "Liquid Hydrogen Sulfide," and J. W. Williams, "The Behavior of Electrolytes in Methyl Alcohol Solutions."

There will be divisional meetings on Wednesday and Thursday mornings, followed by luncheons at the University of Cincinnati. The president's address by Professor William McPherson, "Chemistry and Education," will be given on Wednesday at 8:30 in the Emery Auditorium, following which there will be a musical program.

On the afternoon of Thursday an inspection trip will be made to the Cincinnati Water Works and drive around the city in automobiles, starting from the university immediately after luncheon.

Friday will be devoted to visits to industrial plants, details of which will be announced at the meeting.

SCIENTIFIC NOTES AND NEWS

MRS. ANNA BOTSFORD COMSTOCK, emeritus professor of nature study at Cornell University, distinguished also as a wood engraver, died at Ithaca on August 23, aged seventy-six years. Professor John Henry Comstock, emeritus professor of entomology, survives his wife, but has been seriously ill for several years.

DR. FLORIAN CAJORI, professor emeritus of the history of mathematics at the University of California, died at Berkeley on August 14. Professor Cajori was born in Switzerland in 1859 and received the bachelor's degree from the University of Wisconsin in 1883.

DR. H. H. TURNER, Savilian professor of astronomy at the University of Oxford, died on August 20, while attending the International Congress of Geodesy at Stockholm. Dr. Turner was sixty-nine years old. He had many friends among American astronomers and was delegate from the British Association for the Advancement of Science to the American Association at the last New York meeting.

WHEN Northwestern University at the recent commencement exercises conferred the degree of doctor of science upon Dr. Gotthelf Carl Huber, dean of the graduate school of the University of Michigan, the citation, read by Professor Leslie Brainerd Arey, was as follows: "Distinguished son of the University of Michigan whose filial loyalty has been expressed in a life of unbroken devoted service; respected and loved by students as friend, teacher, and dean; a wise counselor, entrusted by his colleagues with important responsibilities in determining academic policies; fruitful contributor to the fundamental understanding of all branches of microscopical anatomy, whose researches are models of patient, thorough and accurate observation and experiment; pioneer in the application of certain precise methods to the unraveling of difficult morphological secrets; a practical but scholarly scientist occupying a unique position among American anatomists."

DRAKE UNIVERSITY at its forty-ninth commencement conferred upon Dr. Philip Fox, director of the new Adler Planetarium, Chicago, the degree of doctor of laws.

THE honorary degree of master of arts was conferred on June 23 by the University of Michigan on Harlan I. Smith, of the National Museum of Canada.

DR. WILLIAM MCPHERSON, of the Ohio State University, president of the American Chemical Society, will be the guest of honor and principal speaker at a luncheon to be given on September 9, during the meeting of the society in Cincinnati, by the assistant editors and abstractors of *Chemical Abstracts*.

DR. VIKTOR GOLDSCHMIDT, professor of mineralogy at Heidelberg, celebrated the fiftieth anniversary of his doctorate on August 6.

DR. FRIEDRICH EMICH, professor of chemistry at the Technische Hochschule in Graz (Austria), known for his work in inorganic micro-chemistry and analysis, will celebrate his seventieth birthday on September 5.

DR. WERNER HEISENBERG, of the University of Leipzig, has been elected a member of the Saxon Academy of Sciences in the section of mathematical physics. Corresponding members elected include Dr. Johannes Walther, professor of geology and paleontology, and Dr. Edmund O. von Lippmann, professor of the history of chemistry, both of the University of Halle.

A RECENT Order in Council reported in *Nature* directs that the Lord President of the Council (Lord Parmoor), the Minister of Agriculture and Fisheries (Dr. Addison), the Home Secretary (Mr. Clynes), the Secretary of State for Scotland (Mr. W. Adamson) and the President of the Board of Education (Sir Charles Trevelyan) shall be a Committee of the Privy Council for the organization and development of agricultural research. It is also ordered that the Lord President of the council shall be the chairman, and the Minister of Agriculture and Fisheries vice-chairman of the committee.

SIR CHARLES MARTIN, director of the Lister Institute of Preventive Medicine, London, and Professor Arthur Harden retire under the age limit this year and will be succeeded on January 1 by Professor J. C. G. Ledingham and Dr. R. Robison. Sir Charles Martin will take charge of the division of animal nutrition of the Commonwealth Council for Scientific and Industrial Research.

DR. JOSEF HOPMANN, Bonn, has been appointed professor of astronomy in the University of Leipzig.

AT the Iowa Agricultural College and Station at Ames, according to *The Experiment Station Record*, following the resignation of Dr. J. E. Brindley, head of the department of economics, history and sociology since 1913, to allow more time for research in public finance and taxation, Dr. A. G. Black, professor of agricultural economics, has been designated chairman of the department of agricultural economics. Dr. I. E. Melhus, professor of botany, has succeeded Dr. L. H. Pammel as head of the department of botany, the latter remaining as chief botanist in the station. E. M. Mervine, professor of agricultural engineering, has resigned to become associated with the U. S. Department of Agriculture in the investigation and development of sugar beet machinery.

DR. ARCHIE H. ROBERTSON has been appointed director of the State Food Laboratory at Albany, New York. He has been bacteriologist at the Experiment Station at Geneva.

DR. RICHARD S. UHRBROCK has resigned from the faculty of Cornell University in order to accept a position in the division of industrial relations of the Procter and Gamble Company, Cincinnati.

DR. W. A. TAYLOR has resigned from the position of vice-president and chemical director of the La Motte Chemical Products Company, Baltimore.

DR. HOMER L. CUPPLES has been appointed chemist of the Whittier, California, Station of the Bureau of Chemistry and Soils and of the Bureau of Entomology, where he will conduct studies on the toxicity and physio-chemical properties of hydrocyanic acid gas.

DR. S. F. LIGHT, professor of zoology at the University of California, will spend the late summer and autumn in a study of the biology and distribution of the desert termites of southeastern California, with headquarters at Beaumont from August 15 to October 15 and at Palm Springs from that time until the end of December.

DR. ALEŠ HRDLIČKA returned to Washington on August 15 from an expedition to Alaska.

DR. WILLARD BERRY, of the department of geology of the Ohio State University, has returned from France where he attended the hundredth anniversary of the founding of the Geological Society of France. He represented the Geological Survey of Ohio and the Ohio State University.

WILLIAM F. PROUTY, professor of economic and structural geology in the University of North Carolina, has returned with a class of twenty-two students from an eight weeks' transcontinental study tour of the United States, embracing most of the national parks and a number of mining centers.

DR. A. S. EDDINGTON, Plumian professor of astronomy at the University of Cambridge, gave a lecture on "The Inner Construction of Atoms" on the second day of the International Congress of Astronomy, held at Budapest during the second week of August.

AN official American delegation has arrived at Dresden from Washington to study the International Hygiene Exhibition with a view to reporting on the ad-

vances which have been made in hygiene education. The delegation is composed of Dr. Charles Wardell Stiles, of the United States Public Health Service; Major George C. Dunham, of the Army Medical School, and Captain Charles S. Butler, commandant of the Naval Medical School.

GENERAL SMUTS, of South Africa, is leaving on a botanical tour through Rhodesia, the Belgian Congo and Tanganyika as far as Lake Tanganyika. He will be accompanied by a government representative, M. K. Hutchinson, botanist from the herbarium of the Royal Botanical Gardens at Kew, and by Dr. I. B. Pole-Evans, chief of the division of plant industry of the Union, as well as by his brother, J. A. Smuts. The party will collect specimens of flora and will be away for at least six weeks.

SIR CHARLES MARTIN, who has accepted an appointment for two years as chief of the Division of Animal Nutrition of the Australian Council for Scientific and Industrial Research, will sail for Australia late in December, breaking his journey at South Africa to visit the veterinary research station at Onderstepoort. In the meantime he is visiting research institutions in Britain and Germany.

PROFESSOR M. W. WEINBERG, of the Pasteur Institute of Paris, known for his work on anaerobes and gaseous gangrene, will make an official visit to the United States in October and November of this year. He will deliver a series of lectures on bacteriological problems at a number of universities, including the Johns Hopkins, Pennsylvania, Michigan, Chicago, Wisconsin, Iowa, St. Louis and Denver. He will also visit the West Coast and speak before several French societies on the life and work of Pasteur.

THE United States Civil Service Commission announces the following open competitive examinations: Principal civil engineer, $5,600 to $6,400 a year; senior civil engineer, $4,600 to $5,200; senior electrical engineer, $4,600 to $5,200; senior mechanical engineer, $4,600 to $5,200; civil engineer, $3,800 to $4,400, and mechanical engineer, $3,800 to $4,400; for Boulder Dam and the proposed all-American Canal of the Reclamation Service. Applications for these positions must be on file with the Civil Service Commission at Washington, D. C., not later than September 10, 1930. The examinations are to fill vacancies in the Bureau of Reclamation, Department of the Interior, and vacancies occurring in positions requiring similar qualifications, for duty in Washington, D. C., or in the field. Positions in connection with the Boulder Dam Project will be filled from these examinations; also in connection with designs and specifications for the proposed all-American Canal of the Reclamation Service. Competitors will not be required to report for examination at any place, but will be rated on their education, experience and fitness.

THE United States Civil Service Commission announces an open competitive examination for the position of biologist to fill a vacancy in the United States Public Health Service, for duty at Boston, Mass., at $4,200 a year, and vacancies occurring in positions requiring similar qualifications throughout the United States, at entrance salaries ranging from $3,800 to $4,400 a year. The examination is open to both men and women not over forty-five years unless entitled to preference because of military or naval service. The duties of the position are to carry on, under general supervision, advanced biological researches, either individually or in cooperation with others, on animal and human materials, with particular reference to the acceleration or inhibition of cellular growth and similar related researches of a fundamental nature. The Public Health Service is engaged upon such studies, the immediate object of which is to discover some new facts bearing upon the cause and treatment of tumors. Competitors will not be required to report for examination at any place, but will be rated on education, training, experience, fitness and publications.

THE Department of State Employment and Registration, State Employment Commission, Baltimore, announces a vacancy in the position of chief of the Bureau of Chemistry, State Department of Health, at an initial salary of $4,000. The closing date for receipt of applications is September 10, 1930. As a prerequisite for consideration, applicants must have graduated from a college or university of recognized standing with specialization in chemistry; a postgraduate course in chemistry desirable, as well as thorough knowledge of and extensive experience and technical skill in chemical analysis, research and administrative ability, judgment, tact.

Industrial and Engineering Chemistry calls attention to the Basic Science Research Laboratory as a unit of the Institute of Scientific Research of the University of Cincinnati. It brings together representatives of various sciences for a cooperative attack on fundamental problems in borderline fields of pure and, to a lesser extent, applied science. At present attention is largely devoted to the effects of various forms of radiant energy upon living organisms. The laboratory will be open from 3 to 6 on the afternoons of September 9, 10 and 11. Special exhibits will be arronged, and motion pictures will be shown continuously. Guests especially interested in the work of the laboratory are, however, invited to visit it at any time. The laboratory is on the top floor of Cunningham

Hall, University of Cincinnati. The exhibits will include equipment for infra-red spectroscopy for the generation of the "soft" X-rays, and apparatus for the study of the effects of electrons upon bacteria. They will be arranged to show the unique organization of the laboratory, to make clear its aims and review its achievements.

THE first step in the establishment of a forestry school at Duke University, Durham, North Carolina, has been taken in the election of Dr. C. F. Korstian as director of Duke Forest and professor of silviculture in Duke University. Dr. Korstian is at present senior silviculturist at the Appalachian Forest Experiment Station of the U. S. Forest Service, Asheville, North Carolina. Complete plans for the school will not be made until after plans for the forest have been developed and further study has been made of the need for additional forestry training in the South and the opportunities available at Duke for specialized forestry education. Tentative plans for next year provide for a survey, inventory and preliminary management plan. The forest consists of approximately 5,100 acres adjoining the campus. The forest lies in the lower Piedmont region and consists of second-growth shortleaf and loblolly pines, and hard-woods. Because of the representative nature of this tract and because of its size and location it is expected to serve well as a research and demonstration forest. A research program will be developed, taking advantage of opportunities to cooperate with other departments of the university and with other agencies in the region, such as forest schools, state departments and the Appalachian Forest Experiment Station of the U. S. Forest Service. Since the plans for the school are now only partially developed, no curriculum has been made up and it is not planned to give courses next year.

THE late Charles F. Ruggles, lumber merchant of Manistee, Michigan, has bequeathed nearly all his estate, said to amount to $50,000,000, for education and public relief in the State of Michigan.

THE New York Homeopathic Medical College and Flower Hospital will receive thirty-five of the two hundred shares of the Wendel-Swope estate. This great fortune, estimated at one hundred million dollars, or more, will mean that something over seventeen million dollars will come to this institution. This bequest becomes effective on the death of an only surviving sister, Ella Von E. Wendel, who is eighty years old. The will further provides for an immediate gift of two properties at numbers 1 and 3 Third Street, New York City. The Wendel family have been frequent contributors to this college and hospital for more than forty years. At one time Georgiana Wendel was a special student in the college.

DEMOLITION of the "temporary" old mining building at the Pennsylvania State College has been begun as the School of Mineral Industries moved into its new building. The new building is one of the eight the state will officially turn over to the college this October at the celebration of the seventy-fifth anniversary of the signing of the charter; it will be put into use with the opening of college in September. The frame building which is being torn down originally was a temporary home for mechanics arts. Thirty years ago it was moved to its present location and became headquarters for mineral industries as the mining building. Intended to tide over a short period until sufficient funds were available for a permanent structure, the old building continued to serve until this year, although it was long ago inadequate for its purpose.

THE Bureau of Entomology has moved its offices from the brick buildings in the grounds, soon to be razed, to the second floor of wing 3, in temporary building C on Seventh Street near B Street SW. The packers and stockyards division of the Bureau of Animal Industry and the division of cereal crops and diseases of the Bureau of Plant Industry also moved recently to building C, where they now occupy the second floor of wing 2.

Industrial and Engineering Chemistry reports that the Hercules Powder Company on July 30 laid the cornerstone for the main building of new experimental and research laboratories at Hercules, Delaware, which is 3 miles west of Wilmington near the Lancaster Pike. Heretofore the laboratories have been located at Kenvil, N. J., but now they will be much nearer the main office and will be provided with new facilities. It is estimated that the cost of the new construction will exceed $500,000. The site selected comprises more than 300 acres and the new station thus created will be larger and more modern than the present equipment.

MR. LANSBURY, British first commissioner of works, stated recently that the Royal Botanic Society's Gardens, Regent's Park, on the expiry of the crown lease in 1932, would become the property of the public, which would then have free access to them. Questions as to the future of the Botanic Gardens were asked in the House of Commons before the rising of Parliament for the recess. Replying to Lieutenant-Colonel Moore, Mr. Lansbury said it was the intention of the government that the ground should be devoted to some purpose for the benefit of the public, and later, in answer to Sir William Davison, he stated that he

knew of no proposal to clear away the ornamental water or to interfere with the general appearance of the gardens. Yesterday Mr. Lansbury said that the beauty of the gardens would not be destroyed when the lease expired. The gardens would be added to Regent's Park and the public would be able to enjoy them. He added that no doubt provision would be made for carrying on horticultural research work.

DISCUSSION

ARE PLANETS RARE?

IN the August 15 number of SCIENCE Professor Jermain G. Porter challenges a statement of mine that "a planet is a very rare occurrence."

Permit me to quote as authority for this statement Sir James Jeans, who in his "Astronomy and Cosmogony" (1928) follows Chamberlain and Moulton in ascribing the birth of the solar system to the near approach of another star, which is necessarily a rare event. After developing the theory in detail, he concludes (p. 401):

> . . . only about one star in 100,000 is at present surrounded by planets. Planetary systems must then be of the nature of "freak-formations"; they do not appear in the normal evolutionary course of a normal star.

Also Professor A. S. Eddington, in his "The Nature of the Physical World" (1929), p. 177, says:

> The data are too vague to give any definite estimate of the odds against this occurrence, but I should judge that perhaps not one in a hundred millions of stars can have undergone this experience in the right stage and conditions to result in the formation of a system of planets.

To a humble physicist it would seem that Mr. Porter is hardly fair to his fellow astronomers when he says:

> That double stars have planetary systems may be doubtful, but there is absolutely no reason for the assumption that the formation of families of attendant worlds may not be the ordinary course of evolution for the single stars.

Rather than referring to a second-hand account of a press interview with me, in which obviously no arguments or authorities could be presented, would it not have been wiser for Professor Porter to present his case for frequent planets in the astronomical literature for the consideration of Messrs. Jeans and Eddington and others of like mind?

ARTHUR H. COMPTON
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CURIOSITIES OF SCIENTIFIC NAMES

UNDER the above title, Dr. Gifford in a recent number of SCIENCE adds certain instances of "errors in nomenclature," particularly in the coining of new names, and implies that care should be used in seeing that these are bestowed with due regard to classical usage. That this is an excellent principle no one will deny, yet a book full of "odd stories about scientific names" will some day make good reading. The birth of a new scientific name is, with Dr. Gifford, a "serious business," but with those who have much to do with this matter of names the solemnity of the occasion eventually loses somewhat of its glamour. It is, of course, well known that many names are merely anagrams that have no classical counterparts, for names, after all, are nothing more than handles by means of which particular objects are designated. So *Daption* for the Pintado petrel is merely an anagram of that word; *Teonoma* is another formed from *Neotoma,* to designate a genus of similar rats; *Delichon* from *Chelidon* is another instance. But the element of subtle humor comes in where a deliberate play upon words, often inobvious to the uninitiated, is made. It was perhaps a doubtful compliment when one zoologist named a new skunk in honor of a colleague, but when another named a bat *carissima* few might see that it was in honor of its discoverer, Mr. Darling. The term *Kogia,* for a genus of strange looking cetaceans, is said to have been coined by J. E. Gray because it was an odd "codger." In like manner the name *clavium* by Barbour and Allen for the Florida Key deer, to which Dr. Gifford refers, was a deliberate pun, for which the authors are entirely unrepentent, while the name *keyensis* that he suggests would be not only an amateurishly and awkwardly coined word, but would obviously refer equally to Key Island near Papua. There are many other names that hide a bit of humor and all of which, no doubt, are a manifestation of that same twist of human nature that prompted the builders of cathedrals in the middle ages to add to the sacred structure in out-of-the-way places the faces or figures of demons or evil spirits as a relief from the seriousness of their undertakings. The Lincoln Imp is a famous instance.

> So they whistled the Devil to make them sport,
> Who knew that sin is vain.

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T. BARBOUR

PRIORITY IN FAMILY, ORDER AND HIGHER GROUP NAMES

THE International Rules of Zoological Nomenclature provide that a family name shall be formed by adding *idae* to the stem of the type genus, and that if the name of the type genus is changed, the family name shall also be changed. It does not specify how

it shall be changed, however, and there does not seem to be general agreement whether the next younger valid name based on another genus of the family and already in family form should be used, or whether the new name of the oldest or the type genus should be given a family suffix. It would seem desirable to introduce some uniformity of procedure. For example, if the generic name *A-us* 1850, the type genus of the family A-idae 1850, is found to be a synonym of *B-us* 1840, should A-idae be replaced by a newly coined family name, B-idae, in preference to an already proposed name, C-idae 1860, founded on *C-us* 1860, if *C-us* is clearly a member of the same family as *A-us*? And if B-idae should be used in this case, if *A-us* 1850 must be discarded as a newly recognized homonyn and is replaced by *B-us* 1930, should B-idae be the family name? It seems simpler and more consistent with the underlying principles of nomenclature to use C-idae in either case.

The one rule specifically applying to names above family rank is that they shall be uninomial. There seems to be general agreement that although it is desirable to use the older of two synonyms, other things being equal, it is not absolutely essential, if usage has established the later name. For example, Rodentia Smith 1827 is generally used in preference to Glires Linné 1758, and Carnivora Latreille 1825 instead of Ferae Linné 1758. There can be no serious ambiguity in the use of a better-known synonym of later date, but the situation is decidedly different if a homonym is used. The International Rules condemn homonyms for generic and specific names, explicitly and unreservedly. It would seem as if the grounds were equally cogent for the larger groups. To give specific examples, the name Cyclostomata Busk 1852 for a bryozoan order is an exact homonym of Cyclostomata Müller 1834 (= Cyclostoma Rafinesque 1815, also Cyclostoma Latreille 1829, preoccupied by Cyclostoma Lamarck 1801), the lampreys and their relatives. Decapoda Leach 1817, as a subdivision of the cephalopod mollusks, is preoccupied by Decapoda Latreille 1806 in the Crustacea. Tardigrada Illiger 1811 for the tree sloths has precedence over Tardigrada for the water-bears, a Latinization of "Tardigrades" Doyère 1840 (from "le tardigrade" of Spallanzani). In some cases the French form was in use earlier than the date given, but in no case could it reverse the technical priority, as not in Latinized form, nor does it reverse the essential priority, unless, by a stretch of the imagination in the case of "le tardigrade," which is used in the singular referring to an individual and not as a group name. In the case of "Cyclostomata" and "Decapoda," the earlier usage is quite certainly more wide-spread than the later homonym; this is probably not the case with "Tardigrada." In any case, the use of the identical name for entirely distinct groups, besides being slovenly, is a source of possible confusion, especially in bibliographic work. It would seem desirable to discontinue the use of the later term, replacing it with the earliest or best-known valid synonym (for example, Tubuliporina Milne Edwards for Cyclostomata Busk), or if none is available, by a new term.

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THE ORIGIN OF SYMPHORICARPUS

IN a paper entitled "Chromosomes and Phylogeny in Caprifoliaceae," by Karl Sax and D. A. Kribs, published in the *Journal* of the Arnold Arboretum,[1] the authors point out that the genus *Symphoricarpus* is represented in China by only one species, of very limited distribution, whereas the other species are, all of them, natives of North America. Since most of the genera of Caprifoliaceae are most abundant in Asia, and certain genera are found only in China, "it would seem probable," they say, "that the family is of Asiatic origin."

On this assumption they ask the question, "Does this mean that the genus is so old that the original Oriental forms have disappeared and only the newer American species remain?"

Is it necessary to assume that there was ever more than one species of the genus in China? Alternatively may there not have been in North America a species (allied to or even conspecific with the Chinese species and coeval with it) which died out, perhaps through climatic changes? This hypothetical species, now defunct, may first have produced offspring some of which were better adapted to the American climate. By isolation, or otherwise, such species might, conceivably, have given rise to the fifteen (or so) existing American species, which may not all be of equal age.

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ENTROPY AND ORGANIZATION

THE growth of physical concepts depends on the conditions under which they arise. As the context of ideas and experimental facts changes, these concepts also change. From this point of view, it is easy to see how the physical or mathematical probability of an event depends on the assumptions or conventions under which it is calculated. Further,

[1] *Journal* of the Arnold Arboretum, Harvard University, 11 (No. 3): 147–153, July, 1930.

probability depends on the extent of our knowledge of the phenomena in question. This fact has been brought clearly to our attention in the formulation of new statistics by Bose and Einstein, Fermi and Dirac, but has also been pointed out recently in general terms, by Lotka, Eddington and Fry. For definiteness we shall, in what follows, think of the probability of a state as the fraction of the total time of observation in which this specified state is realized. However, such limitation is not necessary for our reasoning, which depends solely on the nature of the mathematical probability.

Though this arbitrary nature of the probability concept has been repeatedly commented on, it does not seem to have been sufficiently emphasized that entropy, being derivable from probability by the Boltzmann formula, is to the same degree indefinite or a matter of convention.

Probability is always "probability-in-the-light-of-certain-kinds-of-facts," those facts, for the physicist, being chosen with reference to energy availability. In a paper at present in course of preparation it is proposed to remove this limitation from the ideas of probability and of entropy and thus permit the extension of these concepts (if necessary, under different names) to aspects of biology and psychology in which the purely physical method of abstraction may not be entirely adequate. Entropy enables us to deal with the organization of inorganic systems but provides a very crude measure for the kind of organization found in living cells and organisms. The use of available energy to produce mechanical work is only one of the activities for which living systems are organized—and not necessarily the most important. By modifying the basis on which our probability is calculated we arrive at a more catholic interpretation of "entropy" by which we can avoid the error of confining our attention only to those aspects of the organism susceptible to analysis by the methods already found successful in much less highly organized matter.

It is suggested therefore that a differentiation be made between the thermodynamic "order" or "disorder" which are measured by classical entropy, and an "organization" or "disorganization" which do not ignore the physiological or psychological features of a given situation and which take account of them in the calculation of the probability.

That there is, in thermodynamics, always an infinite number of expressions homologous with entropy has been pointed out recently by H. J. Brennen, of Northwestern University. We have, in the past, chosen the simplest integrating factor $(\frac{1}{RT})$ for the equation of state of a perfect gas, and thus the entropy obtained is the simplest of these expressions. There is, however, no reason to suppose that nature is interested only in the simplest. Thus, even in the field of thermodynamics itself, there is an arbitrariness about entropy that parallels the above statistical considerations. As this equation has been set up on the basis of purely physical observations the entropies obtained can be measures only of "order" as defined above and not of the more general "organization."

One consequence of this point of view is a realization that the amount of internal energy in a system *actually transformed into work* depends not only on the entropy of the physicist but is subject to the interference of mechanisms, lifeless or living, and of intelligence. Maxwell's demon is the abstract prototype of such mechanisms, which we may call "selecting" mechanisms. They are divisible into two classes according to whether or not they may violate the second law. From the point of view of classical entropy, only the fictitious demon (which bases its action on observations of the microscopic state) can reverse the second law or increase the "order." The other ("valve") mechanisms, which depend for their action on the value of a macroscopic variable, may control the rate at which entropy increases or—more important for the present argument—determine whether or not the available energy will be used at all. Without deciding whether or not the latter mechanisms can interfere with the second law, it is surely desirable to recognize their existence and power to affect the probability and therefore to determine the fate of the energy. There can be no question that they control the more general "organization" of which we have talked.

These ideas throw some light on the so-called "thermodynamic improbability" of the origin and continuous functioning of living organisms. Such systems are improbable only in so far as we are unaware of all the factors operative, including the factors which "emerge" within the system at higher levels of organization in virtue of that organization. The apparent improbability of the organization found in biological structures is duplicated, on a lower level, in simpler systems. For instance, colloid, crystal and surface formations often present a disconcerting degree of organization for which, however, physical chemistry has no terminology at present. This can arise only from the action of the fields of force of the molecules themselves ("selecting mechanisms" for our purpose) and complexity is possible whenever they have free interaction. Such mechanisms can produce this order only at the expense of decrease of order elsewhere in the system. On the other hand, a

biological mechanism can influence the "organization" of matter foreign to itself and therefore may affect the "generalized" entropy.

These considerations are even more striking if the organism acts on the environment by way of its intelligence. Thought interferes with the probability of events, and, in the long run therefore, with entropy. The reason that this fact has escaped the physical analysis is that the physicist intentionally ignores organization which is not primarily organization for energy-availability and admits, further, available energy only in the sense of "available, if we care to, or are clever enough to, apply it for the performance of mechanical work." Actually such energy is available only if suitable mechanisms or intelligence intervene.

The idea of this note and projected paper is to relegate availability of energy to a place compatible with its biological and psychological significance.

I wish to thank Professor K. F. Herzfeld, of the Johns Hopkins, for his great help in the clarification and formulation of my argument and for his criticisms of the present note.

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FEBRUARY 24, 1930

SPECIAL CORRESPONDENCE

RESEARCH WORK OF THE MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

THE departments of physics, geology and electrical engineering of the Michigan College of Mining and Technology are cooperating this summer in continuing the study of the electrical resistibility of various rock formations in the iron and copper districts of Michigan. The work is a part of the general research program of President W. O. Hotchkiss to concentrate research at the college along lines which will be of greatest assistance to the mining industries of the state.

The object of the research studies is to obtain more intimate geological information concerning the districts. This information will be of value in directing exploration in the future.

Professors James Fisher, C. George Stipe, John M. Gaffney and William Longacre and a corps of student assistants of the physics department are studying the electrical resistibility of various formations in the field. This work is being carried on in the region close to the college where conditions are fairly accurately known, but it is planned to extend the research into the iron country. Present indications are that by this method it will be possible in many locations to determine the depth of the water table without drilling. It appears that different kinds of rocks possess different properties of electrical resistivities, and so it is possible by this method to determine geological formations which are covered to a considerable extent with glacial deposits.

In coordination with the work being done by the physics department in the field, Professors Fay L. Partlo, John M. Harrington and T. C. Sermon are in Madison, Wisconsin, doing graduate work in physics for advanced degrees at the University of Wisconsin. They are carrying on research investigations in connection with the physics of rock formations in the upper peninsula which will fit in with the general geophysical research work being carried on at the college. One of the problems which they are studying is the magnetic permeability of different rocks. This study is undertaken to get scientific facts underlying the striking variation in magnetic attractions being used in mapping the geology of the various districts.

Professor C. O. Swanson, Joseph L. Adler and Vincent L. Ayres, of the geology department, are engaged in field geological studies in the iron districts. This work has been going on for the past two years and considerable new information regarding the geological structure and currents in the iron formations has been obtained.

Professor Wyllys A. Seaman, also of the geology department, is engaged in field geological studies in the Copper Country in cooperation with the State Geological Survey and the mining companies. Frank Pardee, assistant state geologist, is in charge of this work. This group of scientists cooperating with the Mohawk Mining Company recently completed a survey of the New Michigan exploration where some valuable information was obtained.

Professor George W. Swenson, head of the department of electrical engineering, is carrying on research work in the American Bell Telephone Company laboratories in New York City. His department is cooperating with the telephone company in trying to determine what causes variations in the strength of radio signals, or why radio signals come in strong sometimes and weak at other times. The Copper Country offers unusual opportunities for this study because the rock formations of this district are of such a nature that there are strong local variations in the earth's magnetic field. These same variations are being used successfully in the geographical mapping of the district.

A CORRESPONDENT

SCIENTIFIC APPARATUS AND LABORATORY METHODS

ANALYSIS OF VOWELS

THE usual analyses of sustained vowels show characteristic distributions of energy on the frequency scale. It has been impossible to make entirely satisfactory syntheses of vowels by combining such fixed, "characteristic" distributions, either through the use of electric oscillators or by means of models of the vocal organs in position.

Furthermore, it is recognized that analyses of vowels based upon such steady-state conditions are not applicable to every-day speech. At the usual rate of enunciation of from four to eight syllables per second it is obvious that steady-state conditions are rarely approximated.

When the orifice and volume of the physiological resonator, the mouth, are varied during the progressive opening of the lips in saying the word "pope," the characteristic resonance frequencies must change rapidly while approximating the steady-state distribution. A similar change will occur at the close of the vowel. These transients constitute a temporal pattern not related to the cycles of the cord tone but an important part of the vowel.

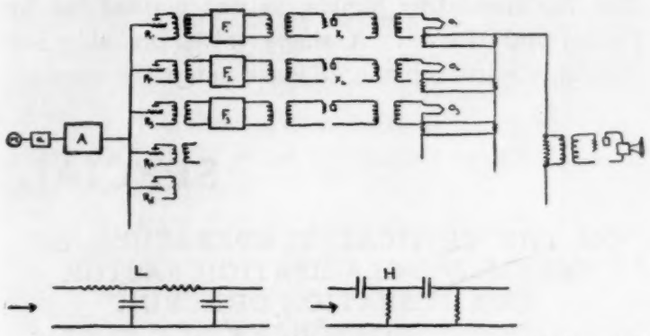
The physiological resonator may not come to a fixed position in the whole course of the spoken or even of the sustained vowel. In the case of the sustained vowel there is always the tremor factor in the fixated muscles of the resonator and in the chest muscles supplying the air-pressure. The pattern of the spoken vowel is certainly one of continuous change.

The vowel in rapid speech must be characterized by a perceptual time pattern of .025 to .200 second duration—a pattern composed of the characteristic transient or transients with their partials in intensity variation. The pattern is to be regarded as an envelop rather than as a group of simultaneous frequencies.

The accompanying diagram indicates a method in process of development for studying the time pattern of the vowels in rapid speech. The disposition of the units is the suggestion of M. S. Mead, of the General Electric Company.

A series of electric filters, perhaps of the resistance-capacitance type,[1] which will be selective for the transient as well as for steady-state pulses, is arranged to pick out bands from the frequency scale. The pulses passing through each of these filter bands are recorded by an individual oscillographic unit.

[1] Shea, "Transmission Networks and Wave Filters," p. 414.



"M" is condenser microphone with associated small amplifier (a) leading to the larger boosting amplifier (A). "R"s are repeater tubes which avoid throwback on the primary circuit—thus making it possible to use one or all filters ("F"s) separately or simultaneously. "X"s are tubes operating oscillographic units ("O"s). The last part of the circuit is an arrangement for synthesizing the analyzed currents. "L" and "H" refer to general type filter circuits (resistance and capacitance).

The parallel tracings of the oscillographs will show the varying intensities of the frequency bands from moment to moment during the course of the vowel. Thus the tracings will give indications from band to band of the time pattern of the transients composing the vowel. Rapid comparison should be possible for a large number of examples of the same vowel or of the different vowels.

The apparatus is so arranged that the pulses passed by the filters can be synthesized and the result of the analysis checked by the actual sound of the vowel which passes through the loud speaker.

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AN ELECTROMAGNETIC PUMP

A DESCRIPTION of an electromagnetic all-glass pump was published recently in this journal[1] by Mr. Henry Rosenberger. It may be worth while to point out that an almost identical piece of apparatus was described in 1926 by Porter, Bardwell and Lind.[2] A double-acting modification of this type of pump was devised by Funnel and Hoover in 1927,[3] and was later improved by Livingston.[4] While the authors of these earlier references were primarily interested in pumps

[1] H. Rosenberger, SCIENCE, 71: 463, 1930.
[2] Porter, Bardwell and Lind, *Journal Ind. Eng. Chem.*, 18: 1086, 1926. See also Francis, *Fuel*, 5: 39, 1926.
[3] Funnel and Hoover, *Jour. Phys. Chem.*, 31: 1099, 1927.
[4] Livingston, *Journ. Phys. Chem.*, 33: 955, 1929.

for circulating gases, only minor changes are necessary to render the apparatus described by them efficient for circulating liquids, as was pointed out by Funnel and Hoover. A single valve, probably less efficient, electromagnetic all-glass pump for circulating liquids was described by Smith and Wood in 1923.[5]

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SPECIAL ARTICLES

ON THE CRITICAL TEMPERATURE OF SERUM: DEPOLARIZATION FACTOR AND HYDRATION OF SERUM MOLECULES

IN a series of papers published recently[1] we have shown, successively, first, that the curve representing the viscosity of serum as a function of temperature presented an absolute minimum around 56° C.; second, that the curve expressing the rotatory power of serum, unaffected by heat up to 54°, suddenly showed an increase around that temperature, and that the subsequent increases were nearly proportional to the temperature; third, that the amount of light scattered at right angles by the serum also began to increase after 55° had been reached.

By application of Lord Rayleigh's formula connecting the amount of scattered light to the volume of the scattering particles, this last value was computed and was shown to increase almost linearly with the temperature, above 57° C. The purpose of this paper is to summarize the results obtained by measuring the depolarization factor of the scattered light. It is known that this light is almost completely polarized vertically in colloidal solutions and that the amount of depolarized light depends on the size, the shape and the anisotropy of the molecules or particles. It is difficult to estimate the part played by the shape, when dealing with particles which are not opaque; Cabannes has shown that, in the case of open chain hydrocarbides, the depolarization factor was independent of the length of the chain.[2] It is therefore probable that the main factors are the size and the optical anisotropy.

It was found that the depolarization factor ϱ begins to increase, just as do the physical properties quoted above, after a certain temperature is reached, namely, 57° C. Its increase is slow at first, then very rapid, and its value may reach 0,50 for pure serum heated for ten minutes at 68°. The increase is continuous, and shows no jump when the sol becomes a gel. After the gel state is attained, the increase goes on, regularly, just as the increase in volume of the molecules, computed from Lord Rayleigh's formula. Table I gives the figures for a normal horse serum, heated ten minutes in sealed tubes.

When the serum is diluted with saline solution (0,9 per cent. NaCl) the depolarization factor may reach, for ten minutes heating at 76°, the extremely high value $\varrho = 0{,}810$. In this case the amount of polarized light amounts to less than 20 per cent. of the scattered light.

TABLE I

Temperature	Norm.	55°	58°	60°	62°	64°	66°	68°
ϱ	0,0175	0,0170	0,0191	0,0282	0,0490	0,0725	0,0832	0,467 coagulated

If an attempt is made to explain the behavior of serum proteins in the aforesaid experiments (viscosity, polarized light, scattered light) it becomes soon obvious that hydration is the main factor. But in order to account for the quantitative side of the phenomena, it is necessary to resort to a new hypothesis concerning the mechanism of hydration. We have shown previously that, after a certain temperature was reached, the rotatory power and the volume of the molecules increased very nearly proportionally to the temperature, and that below a certain temperature nothing happened. We find now that the optical anisotropy of the molecules, expressed by ϱ, increases very rapidly also. If the water molecules were adsorbed at the surface of the protein molecules, these facts would not be comprehensible. If on the contrary we assume that the water molecules can penetrate inside the huge molecular structure of the protein, and in doing so, change the relative position of the groups, the optical phenomena become quite clear. This hypothesis has the further advantage of

[1] P. L. du Noüy, *Ann. Inst. Pasteur*, 42: 742, 1928; 43: 749, 1929; 44: 109, 1930; *J. Gen. Phys.*, 12: 363, 1929.

[2] J. Cabannes, "La diffusion moléculaire de la lumière," p. 135, Paris, 1929.

[5] Smith and Wood, *Journ. Am. Chem. Soc.*, 45: 2632, 1923.

explaining the reason of a threshold, around 55° C., and the proportionality to temperature of the phenomena: as long as the kinetic energy of the water molecules does not reach a certain value, the forces binding the external groups of the protein together will not let them in. When the critical temperature is reached, it simply means that the kinetic energy of the water molecules is of the same order of magnitude, and that they can force their way through. From that moment on, the amount of molecules which will penetrate is directly proportional to their energy, that is to say, to the temperature. The volume of the protein molecules will then increase until they occupy the whole volume of the solution: the sol becomes a gel. As the concentration of proteins in horse serum, for instance, is high (about 7 per cent.), and as the volume occupied by these molecules, expressed in per cent. of the total volume, is roughly equal to 11, it means that if the molecules of protein increase their volume nine times, they will be in contact with no free solvent between them; in this case, their mean diameter is only increased about twofold. Such an amount of hydration (900 per cent.) is not at all in contradiction with what is known concerning the capacity of hydration of proteins. Marinesco[3] has found for egg-albumin values as high as 1.300 per cent.

A detailed paper will appear shortly and bring forth a few more facts in favor of this hypothesis.

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ELECTROMAGNETIC RADIATION AND THE PROPERTIES OF THE ELECTRON

THERE is weighty evidence, I have shown,[1] that the link between electromagnetic radiation and the electron, which engages the attention of physicists very much at present, is represented by certain properties of the electron. I would like to point out here additional evidence. Consider an electron gas kept at constant temperature, through which two beams of *continuous* electromagnetic radiation of equal intensities parallel to each other are passed in opposite directions. Suppose that the electrons consist of perfectly reflecting particles. On account of their motion the radiation will exert a pressure tending to decrease their velocities continually. But on the average this can not happen. The electrons therefore regain their velocities during the collisions, which can happen only through an increase of their fields during the process; and hence their fields decrease during the intervals between collisions. The increase in electric potential energy during the collisions can be derived only from the internal energy of the electrons, which can be replenished only through an absorption of radiation, into which the kinetic energy lost was initially converted. The electrons thus absorb radiant energy during their motion which is stored up as internal energy and which is attended by a decrease in their electrical fields.

Now suppose that the intensities of the two beams are varied in such a manner that the velocity of a selected electron of the gas is not influenced through the change of the distribution of the pressure of the beams and surrounding radiation acting upon the electron. If further we suppose that the absorption of radiation takes place in such a manner that no force is exerted upon the electron, it would proceed indefinitely with a constant velocity while absorbing radiation, whose total amount may become infinitely large. But this is impossible. Hence the absorption of radiation takes place asymmetrically and in such a way that a force is introduced acting contrary to the motion of the electron, and in a degree that when the motion is reduced to zero the absorption ceases. Hence if v_0 denote the velocity of the electron at the beginning and v that at the end of a free path, the change in momentum under these conditions is given by

$$m (v_0 - v) = k_1 h \Sigma \; k_2 \nu / c$$

where m denotes the mass of the electron, h Planck's constant, c the velocity of light, ν the frequency of radiation, and k_1 and k_2 denote constants. The amount of internal energy converted during the collision at the end of the path into kinetic energy and radiation by acceleration will be less than twice the change in kinetic energy, since the acceleration is produced by a recovery of the field. The difference

$$k_3 h \Sigma k_2 \nu - m (v_0^2 - v^2)$$

is therefore the minimum amount of internal energy that at some part of the path (probably where collision occurs) is reconverted *directly* into radiation, where $k_3 \; h \; \Sigma \; k_2 \; \nu$ denotes the energy absorbed over the path, k_3 being a constant equal to or greater than k_1. This expression may be written

$$\left(k_3 c - k_1 (v_0 + v) \right) \frac{h \Sigma k_2 \nu}{c}$$

by means of the above equation. It is evidently a positive quantity, and electronic internal energy is thus converted *directly* into radiant energy under these conditions. They will, no doubt, occasionally be satisfied by the radiation surrounding an electron without any external assistance. Internal energy will also obviously be directly converted into radiation

[3] N. Marinesco, *C. R. ac. Sc.*, 189: 1274, 1929; 187: 718, 1929.

[1] *Phil. Mag.*, 7: 493, 1929; SCIENCE, 70: 478, 1929; 61: 340, 1930; *Nature*, 124: 728, 1929.

whenever the radiation absorbed by an electron in passing over a free path is greater than the increase in kinetic energy and energy radiated through acceleration during collision.

If the electron consists of a packet of radiation, as de Broglie and Schrödinger suppose, it is all the more likely to possess the above properties.

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INTERPRETATIONS OF THE CURVE OF NORMAL GROWTH

ALTHOUGH there seems to be a striking similarity between the course of growth in animals and plants and the courses followed by the autocatalytic curves as described by Robertson[1] and Crozier,[2] it seems doubtful whether such a complicated process as growth would follow so simple a chemical reaction. A growth equation embodying a general biological rather than a chemical interpretation of the growth process may be derived in the following manner. Minot[3] showed for a number of animals that the percentage increments in body weight $\frac{W_2 - W_1}{W_1}$ tend to decrease constantly from birth to maturity. Child[4] explains this decrease in the percentage increments as due to the ever-increasing mass of inactive protoplasm in the body cells accompanying growth and differentiation. As the mass of inactive protoplasm increases, the mass of active protoplasm decreases and hence the relative rate of metabolism decreases, which in turn brings about a decrease in the reproductive or growth power of the cells. These percentage increments may be looked upon as measuring the average growth power of the body cells, if growth power may be defined as the percentage rate of increase in growth. Wright[5] suggested briefly that the hypothesis that growth power falls off at a constant percentage rate leading to the curve

$$\log \log \frac{c}{W} = a - kt \qquad (1)$$

might often give a good fit to growth data. This equation may also be expressed in the forms

$$\log W = A - be^{-kt} \qquad (2)$$

and

$$L = Be - Ce^{-kt} \qquad (3)$$

Dr. Wright found that equation (1) gave a very good fit to growth in weight W of rabbits. Equation (2) was found by Davidson[6] to give a good fit to growth in weight W of dairy cattle. Equation (3) was applied by Weymouth[7] with excellent success to growth in length L of the razor clam.

The derivation of equation (2) is as follows: $\frac{dW}{Wdt} = P$ where W equals body weight at any time t, and P equals the growth power of the body cells. Since growth power is assumed to fall off at a constant percentage rate, $\frac{dP}{Pdt} = -k$. By integration $\log P = -kt + C$, or $P = e^{C - kt} = \frac{dW}{Wdt}$. By integration again, $\log W = -\frac{1}{k} e^{C - kt} + A$, or $\log W = A - be^{-kt}$. In the last equation A is the logarithm of the weight of the animal at maturity; 100k is the constant percentage rate of decrease in growth power according to the above interpretation, and b locates the curve in time; W is the weight at any time t. The equation of the curve for weight W is $W = e^{A - be^{-kt}} = Be^{-be^{-kt}}$ where $e^A = B$. This equation is similar to equation (3) for length L and is S-shaped with the point of inflection at approximately 37 per cent. of the final weight. It differs from the growth curves of Robertson and Crozier in that it embodies a general biological rather than a chemical interpretation of the growth process and at the same time requires the utilization of fewer velocity constants.

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[1] T. B. Robertson, *J. Gen. Physiol.*, 1925–1928, 463, 1926.

[2] W. J. Crozier, *J. Gen. Physiol.*, 10: 53, 1926.

[3] C. S. Minot, "Age, Growth and Death," G. P. Putnam's Sons, New York, 1908.

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